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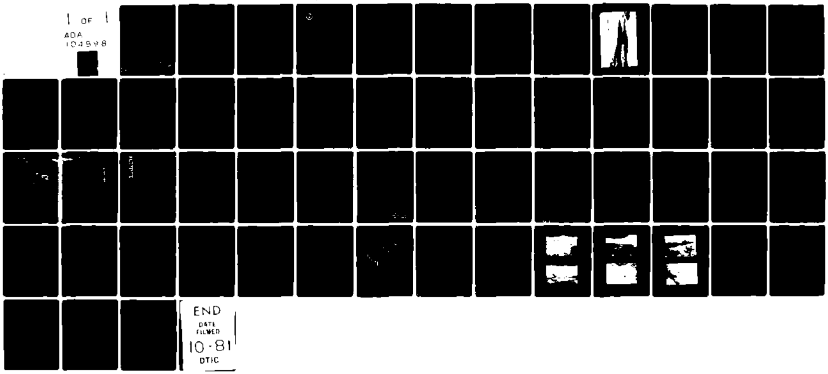

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AD A104898

CRYSTAL LAKE DAM
JEFFERSON COUNTY, MISSOURI
MO 30462

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER 1978

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National Dam Safety Program
Crystal Lake Dam (MO 30462)
Jefferson County, Missouri

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Crystal Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Crystal Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood.
2) Overtopping could result in dam failure.
3) Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: Arthur L Johnson for Chief, Engineering Division — 28 Sep 78 Date

APPROVED BY: Leon G. McKinney Colonel, CE, District Engineer — 29 Sep 78 Date

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CRYSTAL LAKE DAM
JEFFERSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30462

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

SEPTEMBER 1978

HS-7848

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Crystal Lake Dam
State Located:	Missouri
County Located:	Jefferson
Stream:	Tributary La Barque Creek
Date of Inspection:	28 June 1978

The Crystal Lake Dam was visually inspected by engineering personnel of the office of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of the inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

At the time of the visual inspection the lake was being drained, with the depth of water remaining in the lake estimated to be approximately 3 feet. According to the owner, the lake was being drained preparatory to making certain repairs to the dam and lake bottom. This repair work is scheduled for sometime this summer. It was reported that the major remedial measures to be undertaken will consist of reconstruction of the upstream face of the dam in areas where the slope has sloughed, and sealing with clay the lake bottom in suspected seepage areas.

Based on a visual inspection, it is evident by the general condition of the dam and appurtenances that repairs to these features are in order. The following deficiencies, some of which the owner is aware and is planning to correct when the remedial work is performed this summer, were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. The lower section of the upstream slope of the dam, beginning at a point about 20 feet below the dam crest and extending for about 200 feet across the central area of the dam, has sloughed appreciably. Material lost from the slope is believed to have settled into the lake bottom below the waterline.

2. The downstream toe of slope in a location near the center of the dam was found to be soft and slightly wet. It is believed that this condition is due to seepage from the lake.

3. The 24-inch by 30-inch concrete box culvert provided for spillway flow, crossing the road just below the dam, was found to be nearly one-half full of sediment. In addition, the remains of the original form lumber, used during construction of the culvert, were noticed at both ends of the structure. The capacity of the culvert will be reduced due to the loss of waterway area negated by the sediment and construction debris.

4. The spillway consists of an excavated earth section located at the left (looking downstream) abutment. An outlet channel with a low embankment on the right side to confine the flow, directs flow leaving the spillway crest to a point below the dam where it is required to enter a 24-inch by 30-inch culvert under the road adjacent to the dam. The flow then proceeds downstream via an unimproved channel to the juncture with the original stream course. The culvert also intercepts drainage from storm runoff of the area north of the dam and west of the road. The embankment face between the road and the upstream end of the stream channel is unprotected and, with a slope of 1v on 2h, is subject to erosion during certain spillway discharge conditions. Since it was determined that lake outflow for certain flooding conditions will exceed the capacity of the 24-inch by 30-inch culvert, it is expected that the road will be overtopped. The flow path will be across the low point of the road and down the unprotected slope.

5. The upstream slope has a grass cover to protect it from erosion by wave action. A grass covered slope is not considered adequate to prevent erosion by continued wave action. Continued erosion of the bank will reduce the cross section of the dam that could result in further sloughing, instability, and/or settlement of the dam crest.

According to the criteria set forth in the recommended guidelines (see text) the spillway design flood for this dam, which is classified as intermediate in size and of high hazard potential, is specified to be the probable maximum flood (PMF). PMF is the flood that may be expected from the most severe combinations of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Results of a hydrologic/hydraulic analysis indicated the existing spillway to be inadequate to pass lake outflow resulting from a storm of PMF magnitude; however, it is adequate to pass lake outlfow resulting from the 1 percent chance (100-year frequency) flood. The existing spillway is capable of passing lake outflow corresponding to about 29 percent of the PMF. The length of the downstream damage zone, should failure of the dam occur, is estimated to be four miles.

A review of available data did not disclose that seepage analyses as indicated in the recommended guidelines, nor stability analyses of the dam were performed. This is considered to be a deficiency and should be rectified.

It is recommended that the owner take the necessary action, without delay, to correct the deficiencies and safety defects reported herein.

Albert B. Becker, Jr.

Albert B. Becker, Jr.
P.E. Missouri E-9168

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CRYSTAL LAKE DAM - ID NO. 30462

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CRYSTAL LAKE DAM - ID NO. 30462

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. National Dam Inspection Act, Public Law 92-367, dated 8 August 1972.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams" Appendix D to "Report of the Chief of Engineers on the National Program of Dams, dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Crystal Lake Dam is an earthfill type embankment rising approximately 42 feet above the original stream bed. Lake level is governed by an excavated earth type spillway section located adjacent to the left (looking downstream) abutment. The spillway is grass covered. At normal pool the lake surface occupies approximately 4 acres. A 2-inch diameter pipe, with a valve located near the downstream end, serves the lake for drawdown purposes. Location of the lake in the Lakewood Hills Subdivision is shown on Plate 2.

b. Location. The dam and lake are located on an unnamed tributary of La Barque Creek, approximately 5 miles southeast of Pacific, Missouri, in Jefferson County, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Section 33, Township 43 North, Range 3 East, approximately one-half mile west of the intersection of State Routes F and FF.

c. Size Classification. The classification for size based on the height of the dam and storage capacity is categorized as intermediate. (Per Table 1, Recommended Guidelines for Safety Inspection of Dams.)

d. Hazard Classification. The Crystal Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that the dam is located where failure may cause loss of life, serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District extends four miles downstream of the dam. Within the possible damage zone are three homes, two improved road bridges, and one county road bridge.

e. Ownership. The lake and dam are owned by George J. Cyrus & Co., Inc., developers of Lakewood Hills, a residential community. The corporation is located at 2929 Central Street, Evanston, Illinois, 60201.

f. Purpose of Dam. The dam impounds water for the purpose of private recreation for surrounding residential property owners, who are members of the Lakewood Hills Property Owners Association.

g. Design and Construction History. According to the owner, the dam was constructed about 1966 for the development of Lakewood Hills subdivision. The builder was a local contractor by the name of Gephardt who reportedly was experienced in the construction of small, earthfill dams. Mr. Gephardt's present status and location are unknown. No design data or construction records are known to exist. As previously stated, the lake is presently being drained in order to make repairs to the dam and lake bottom.

h. Normal Operational Procedure. The lake level is unregulated.

1.3 PERTINENT DATA

a. Drainage Areas. The area tributary to the lake, with the exception of several residential lots adjacent to the lake, is virtually undeveloped and covered with timber. The watershed above the dam amounts to approximately 45 acres. The watershed area is outlined on Plate 1.

b. Discharge at Damsite.

(1) Estimated maximum flood at damsite ... Unknown

(2) Spillway capacity ... 180 cfs (estimated)

c. Elevation (ft. above MSL). The intersection of the roadway centerlines of Red Bud Drive and Crabtree Lane (see Plate 2) was assumed to be elevation 595. The basis of this assumption being the contours, at 10-foot intervals, shown on the 1954 Pacific Missouri Quadrangle Map, 7.5 minute series, photo revised 1968. The following elevations were measured in the field using the above benchmark.

(1) Top of dam ... 580.3 (min.)

(2) Normal pool (spillway crest) ... 578.6

(3) Streambed at centerline of dam ... 539.0±

(4) Maximum tailwater ... Unknown

d. Reservoir.

(1) Length of normal pool (elevation 578.6) ... 650 ft.

(2) Length of maximum pool (elevation 580.3) ... 700 ft.

e. Storage.

(1) Normal pool ... 50 ac.ft.

(2) Top of dam (incremental) ... 7 ac.ft.

f. Reservoir Surface.

(1) Top of dam ... 5 acres

(2) Normal pool ... 4 acres

g. Dam.

(1) Type ... Earthfill

(2) Length ... 600 ft.

(3) Height ... 42 ft.

(4) Top Width ... 15 ft.

(5) Side Slopes

(a) Upstream ... 1v on 3h

(b) Downstream ... 1v on 2.1h

(6) Cutoff ... Unknown

(7) Slope Protection

(a) Upstream ... Grass

(b) Downstream ... Grass

h. Spillway ... Excavated earth, grass covered

i. Outlet for Lake Drawdown.

(1) Type ... Steel pipe, 2-inch diameter

(2) Length ... 250 ft. (estimated)

(3) Control ... Valve, manually operated

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the design of the dam is known to exist.

2.2 CONSTRUCTION

The dam was constructed about 1966 by an unknown contractor from Pacific, Missouri. No additional construction data are available.

2.3 OPERATION

The lake has, apparently throughout its life, experienced considerable leakage. According to investigations made in June, 1976, by the Missouri Department of Natural Resources, Division of Geology and Land Survey, Reference Chart 2-1, it was concluded that flow was leaving the lake at the contact area with the parent bedrock, sandstone of the St. Peters Formation, exposed in the bottom and sides of the lake. A visual inspection of the dam was performed in September, 1976, by the Layne-Western Company, Inc., of Kirkwood, Missouri, Reference Charts 2-2 and 2-3, and subsequently a detailed seepage investigation was made during October and November of 1976, Reference Charts 2-4 through 2-14, by the same company. Investigations by Layne-Western consisted of measuring the amount of seepage at two locations downstream of the dam, recording changes in the lake level, determining the approximate surface area of the lake, and a visual inspection of the area. The Layne-Western report also concluded that seepage loss was occurring through the sandstone bedrock and that the rate of leakage from the lake was on the order of 14.5 gpm at the time of the investigation. In their report, Layne-Western recommended that the lake be sealed by lining the bottom and sides of the lake with

clay. According to the owner, it is planned to proceed with this method of repair sometime this summer (1978).

According to the owner, the lake has not, to date, overflowed the spillway.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were not available.

b. Adequacy. No formal design or construction data were available. The investigations by the Layne-Western Co. are considered to be for the purpose of quantifying the leakage from the lake and for making recommendations to reduce the leakage therefrom. No indication of seepage analyses relating to the stability of the dam, as indicated in the recommended guidelines, was found.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the dam and spillway was made by Horner & Shifrin engineering personnel on 28 June 1978. Also inspected at this time was the area downstream from the dam, including the juncture of the tributary with La Barque Creek and the various downstream road crossings and homes between the dam and the Meramec River. Photographs of the dam and appurtenant structures taken at the time of the inspection are included on Pages A-1 through A-3 of the Appendix.

b. Dam. Sloughing of the upstream slope (see Photo 1), beginning at a point approximately 20 feet below the top of dam and extending for about 200 feet across the central area of the dam, was observed. At the time of the inspection the depth of water in the lake was estimated to be approximately 3 feet. The slope did have a substantial turf cover. The crest and downstream slope (see Photo 2) of the dam appeared to be in good condition with a substantial cover of turf. The downstream toe of slope was noticeably damp and soft in areas near the center of the dam.

The elevation of the top of the dam near the right (looking downstream) abutment, as determined by survey, was found to be approximately 3 feet lower than the top of dam in the area near the center of the dam. A profile of the dam crest centerline is shown on Plate 3.

c. Spillway. The crest area of the excavated earth spillway section (see Photo 3) was found to be in satisfactory condition with a substantial turf cover. A 4-inch diameter riser pipe was noticed embedded in the spillway crest. According to the owner, this pipe is believed to be an outlet pipe for overflow of a nearby septic tank. The spillway outlet channel appeared to be in good condition between the dam and the roadway below the dam. In some

areas, where the section was used for vehicular access to the dam, the turf cover was sparse. Minor erosion of the section adjacent to the channel training wall (embankment) on the right side was noticed. The concrete box culvert (see Photo 4) at the roadway below the dam was partially filled with sediment. In addition, the lumber used to form the waterway section had not been removed at the time of construction. The outlet channel downstream from the culvert was found to be densely covered with trees and brush. A profile of a portion of the spillway outlet channel flowline is shown on Plate 3.

d. Reservoir. As stated in paragraph 3.1b., the depth of water in the lake at the time of the inspection was estimated to be 3 feet. Sandstone outcroppings (see Photo 5) were noticed below the elevation of the spillway in areas along the left side of the normally submerged lake area.

e. Drawdown Pipe. A 2-inch steel pipe (see Photo 6) with a manually operated valve was observed just downstream from the access road below the dam. At the time of the inspection, the valve was open and flow was being discharged.

f. Downstream Channel. The downstream channel is unimproved. The stream joins La Barque Creek approximately 0.5 mile below the dam. La Barque Creek joins the Meramec River about 4 miles below the dam.

3.2 EVALUATION

Major defects, including reconstruction of the upstream slope of the dam and sealing of the lake bottom, observed during this inspection are, according to the owner, planned to be corrected sometime this summer (1978) when a contract for remedial work on the dam and lake area is awarded. The remaining deficiencies observed during the inspection are not considered of major consequence to warrant immediate remedial action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The water surface level is governed by rainfall, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM AND SPILLWAY

Based on the appearance of the dam and spillway, it would seem that they receive maintenance on a regular basis. An exception would be the concrete box culvert crossing the road below the dam. The culvert waterway is restricted by the presence of sediment and form boards. As mentioned in paragraph 3.2, repairs to the dam and lake floor are planned by the owner for sometime this summer.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

The only item capable of being operated at this dam is the valve on the 2-inch lake drawdown pipe. According to the owner, the valve is in good operating condition. The valve was fully open and discharging lake water at the time of the inspection.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection did not reveal the existence of a dam warning system.

4.5 EVALUATION

A well-maintained dam is considered beneficial to the continued operation and safety of the dam.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were developed from the USGS Pacific, Missouri, Quadrangle Map. The proportions and slopes of the spillway and dam were developed from surveys made during the inspection.

c. Visual Observations.

(1) The excavated earth spillway section is in good condition. According to the owner, the lake level has never been high enough to result in flow over the spillway. Some erosion is evident in the grass covered earth outlet channel downstream of the spillway crest, probably as a result of local runoff following rainfall.

(2) A 2-inch diameter pipe with valve is provided to dewater the lake.

(3) The spillway and outlet channel are located in the left abutment. Spillway releases within the limited capacity of the spillway section will not endanger the integrity of the dam.

d. Overtopping Potential. The spillway section is too small to pass the probable maximum flood or the 1/2 probable maximum flood, but will pass the 1 percent chance (100-year frequency) flood, without overtopping the dam. The results of a dam overtopping analysis are as follows:

Ratio of PMF	Q - Peak Outflow (cfs)	Max. Lake Water Surface Elevation	Height of Flow Over Dam (Elev. 580.3)	Duration of Overtopping of Dam (Hours)
0.29	180	580.3	0	0
0.50	350	581.0	0.7	0.5
1.00	970	582.0	1.7	1.25
100-Year Flood	140	580.1	0.0	0.0

.ie flow safely passing the spillway just prior to overtopping amounts to about 180 cfs, which is equivalent to the outflow from about 29 percent of the probable maximum flood and exceeds the outflow from the 1 percent chance (100-year frequency) flood.

Procedures and data for determining the probable maximum flood, the 100-year frequency flood and the discharge rating curve for flow over the spillway and dam crest are presented on Pages B-1 and B-2 of the Appendix. A listing of the HEC-1DB input data is shown on Pages B-3 through B-5 of the Appendix.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist.

c. Operating Records. No appurtenant structures or facilities requiring operation, other than the lake drawdown pipe, exist at this dam. The only records obtained since construction of the dam are the data compiled by Layne-Western during their seepage investigation of October and November of 1976. These data are included in their report as indicated in Section 2, paragraph 2.3.

d. Post Construction Changes. According to the present and former owners, no man-made post construction changes exist which will affect the structural stability of the dam.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated the excavated earth spillway to be capable of passing lake outflow of about 180 cfs without the level of the lake exceeding the low point in the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d., indicated that for storm runoff of probable maximum flood magnitude the lake outflow would be on the order of 970 cfs, and for the 100-year frequency flood the lake outflow would be approximately 140 cfs.

Several items were noticed during the visual inspection that adversely affect the safety of the dam. Among these were sloughing of the upstream slope of the dam, lack of erosion protection on the upstream face, damp and soft areas at the downstream toe of slope, a hydraulically inadequate and obstructed culvert in the spillway channel at the toe of the dam, and erosion of the spillway channel between the crest and the toe of slope.

No stability or seepage analyses relating to the stability of the dam, nor hydraulic analyses of the spillway, are known to exist.

b. Adequacy of Information. Due to the lack of engineering design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The report by Mr. Dean (reference Chart 2-1) and the reports by the Layne-Western Co. (reference Charts 2-2 thru 2-14) were also used to aid in evaluating the condition of the dam and adjacent areas. Those recommendations with regard to the hydrology of the watershed and the capacity of the spillway were based on a hydraulic/hydrologic study.

c. Urgency. The safety defects noted in paragraph 7.1a should be investigated without delay and if possible prior to allowing the lake to refill,

since failure of the dam could result from overtopping and instability. The remaining items recommended in paragraph 7.2 should be accomplished in the near future.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Spillway size and/or height of dam should be increased to pass lake outflow resulting from a storm of probable maximum flood magnitude.

(2) Increase capacity of box culvert to allow spillway design flood to pass without overtopping the road.

(3) Obtain the necessary soil data and perform stability and seepage analyses in order to determine the structural stability of the dam for all operational conditions.

(4) Inspect the downstream toe of dam and the outlet channel below the dam for evidence of seepage after the lake is allowed to refill and upon completion of remedial work to be undertaken this summer.

b. O & M Maintenance and Procedures. The following O & M maintenance and procedures are recommended:

(1) Restore the eroded portion of the spillway outlet channel and provide some form of protection in this area to prevent future erosion by spillway flow or storm water runoff.

(2) Investigate the purpose of the riser pipe located in the spillway control section. Remove or plug the pipe with grout in order to seal the opening and prevent loss of section through the spillway.

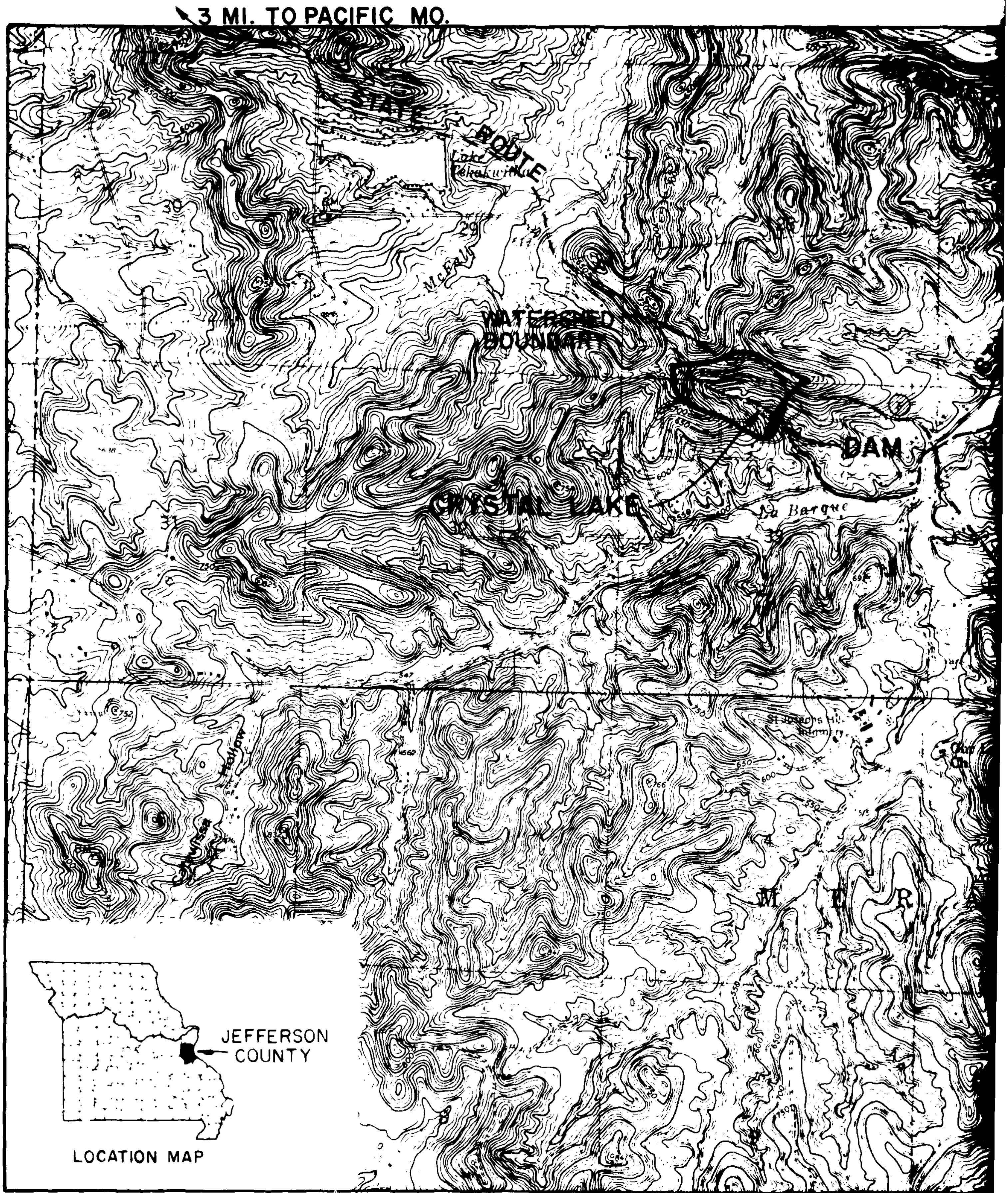
(3) Remove sediment and construction debris from culvert crossing access road below the dam in order to provide full waterway area.

(4) Provide some form of slope protection between the access road and outlet channel in order to prevent erosion of the embankment should lake outflow exceed the capacity of the box culvert and overtop the road.

(5) Provide some form of slope protection for the upstream face of the dam at and above the normal water line to prevent erosion by wave action.

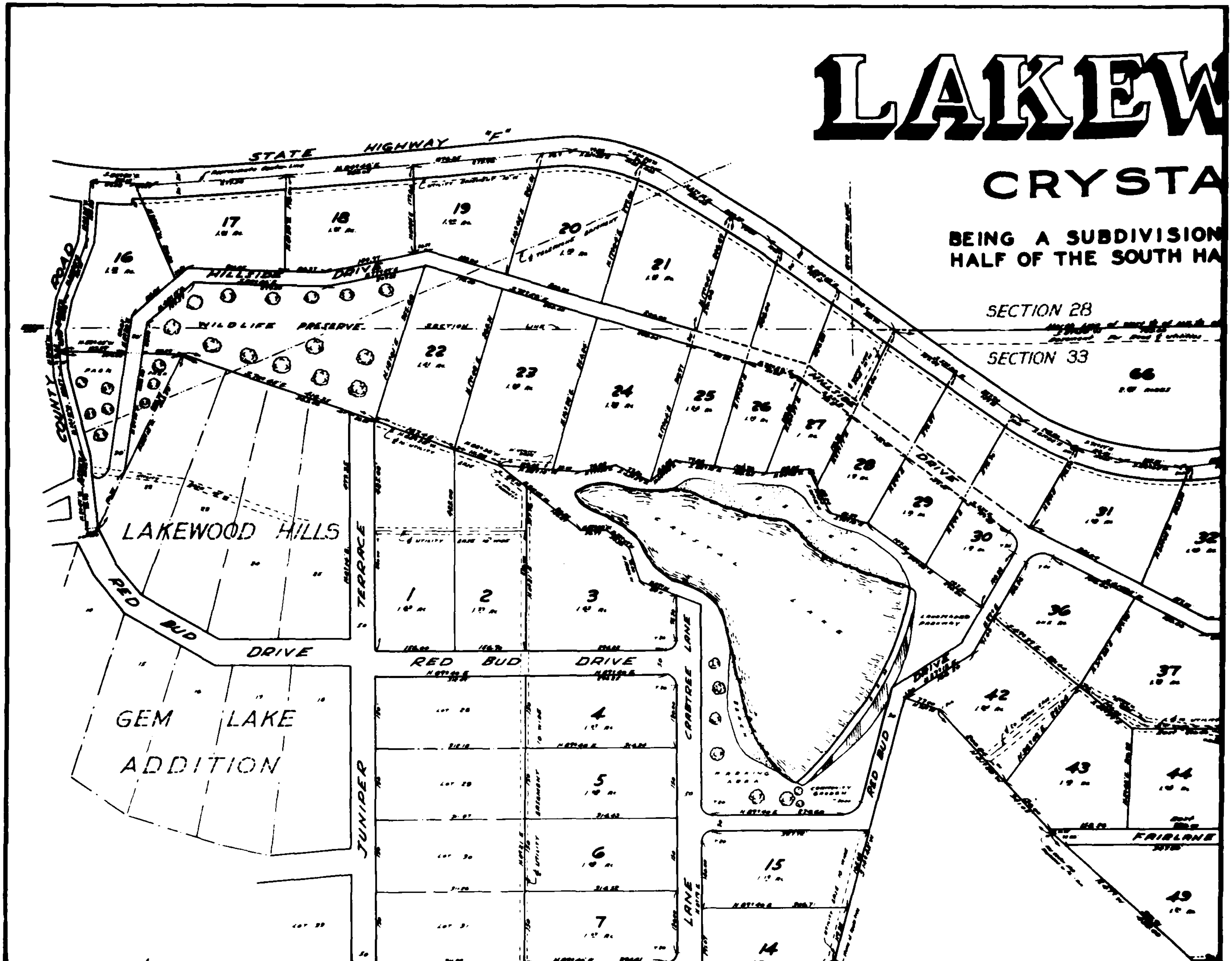
(6) Inspect the outlet end of the 2-inch steel pipe on a regular basis for evidence of corrosion and signs of earth materials being transported by flow. Corrosion of the steel pipe is probable and could result in loss of embankment materials due to piping.

(7) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of earthfill type dams. It is also recommended, for future reference, that records be kept of all inspections and remedial measures.


3 MI. TO PACIFIC MO.
STATE ROUTE
WATERSHED BOUNDARY
DAM
CRYSTAL LAKE
La Barque
JEFFERSON COUNTY
LOCATION MAP

REGIONAL VICINITY MAP

PLATE I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WILDLIFE PRESERVE
LAKEWOOD HILLS
RED BUD DRIVE
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TERRACE
JUNIPER
CRABTREE LANE
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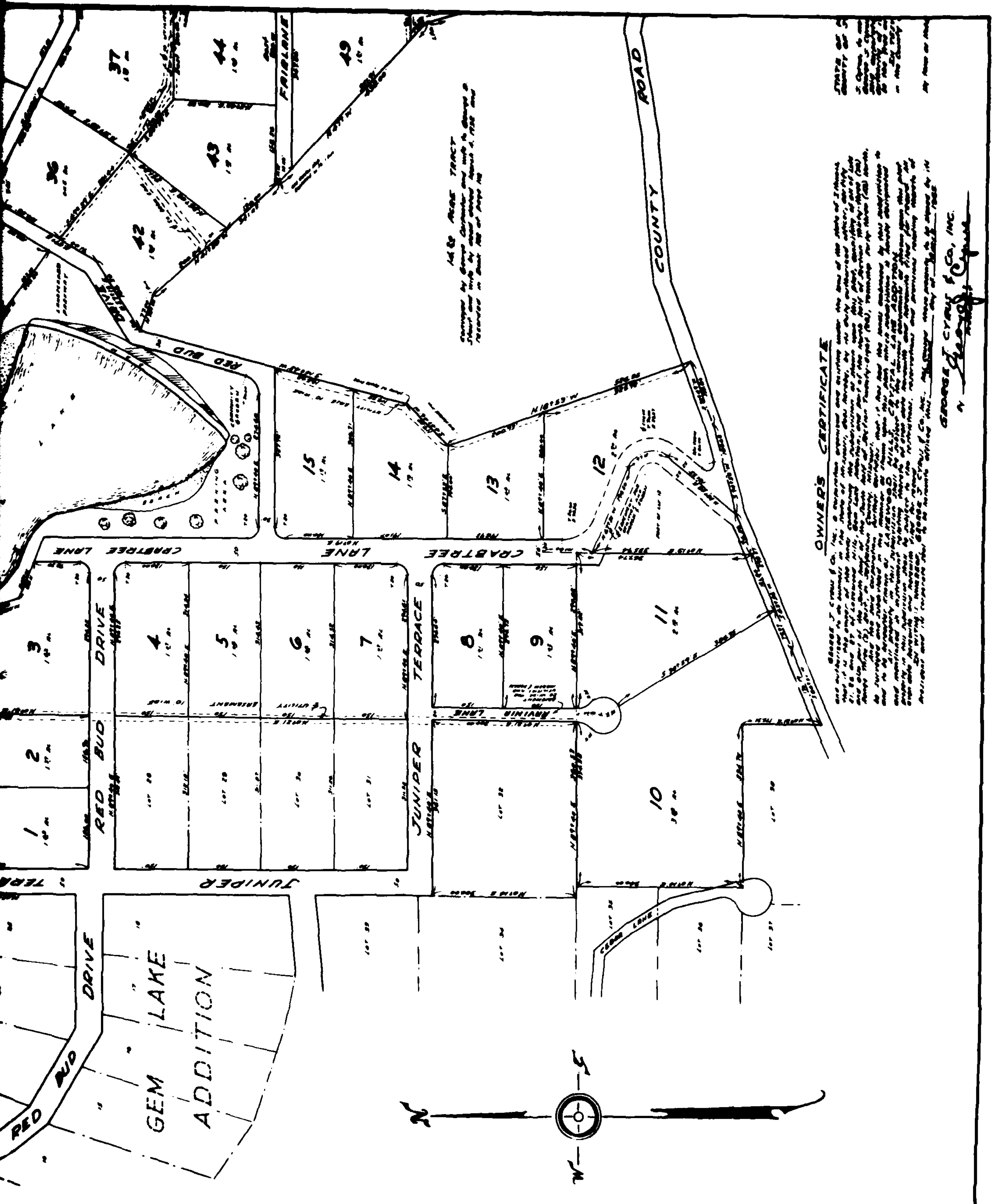
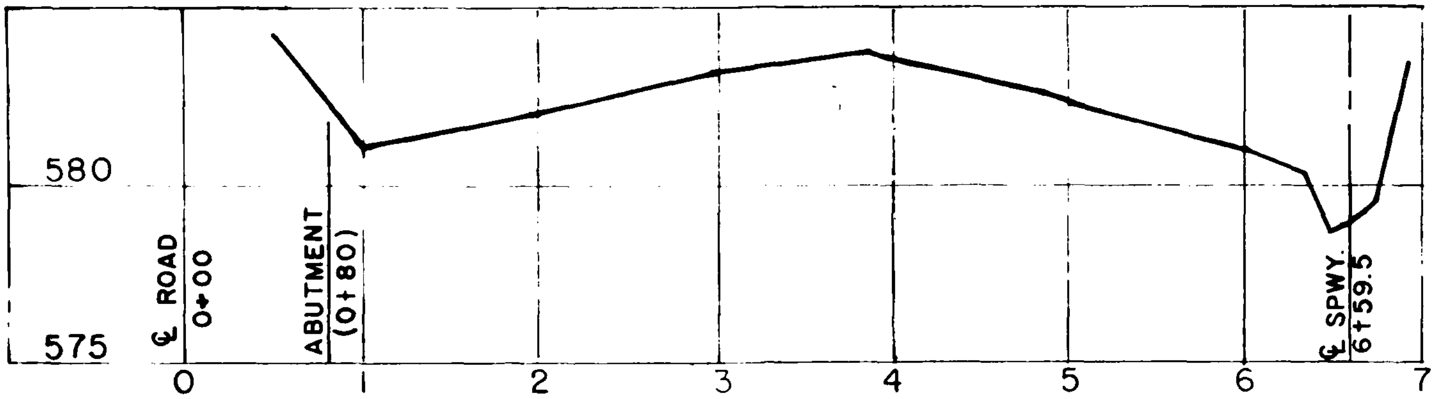


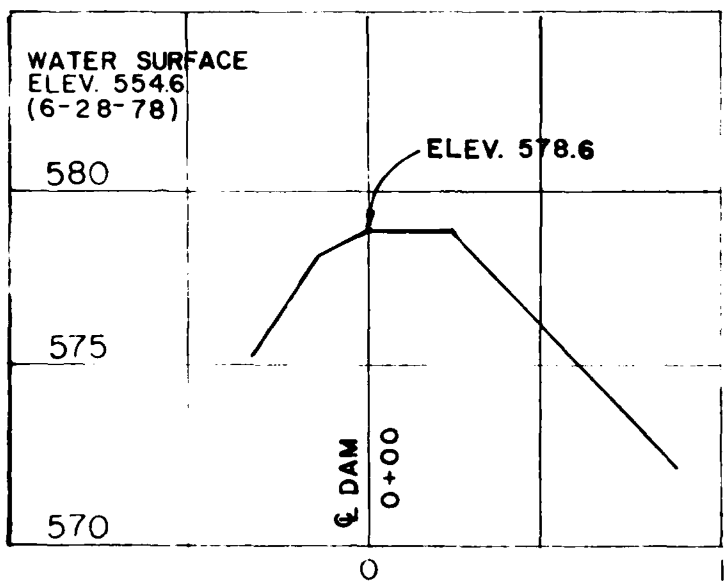
SUBDIVISION PLAT

2

PLATE 2



PROFILE DAM CREST
SCALES: 1" = 5' V., 1" = 100' H.



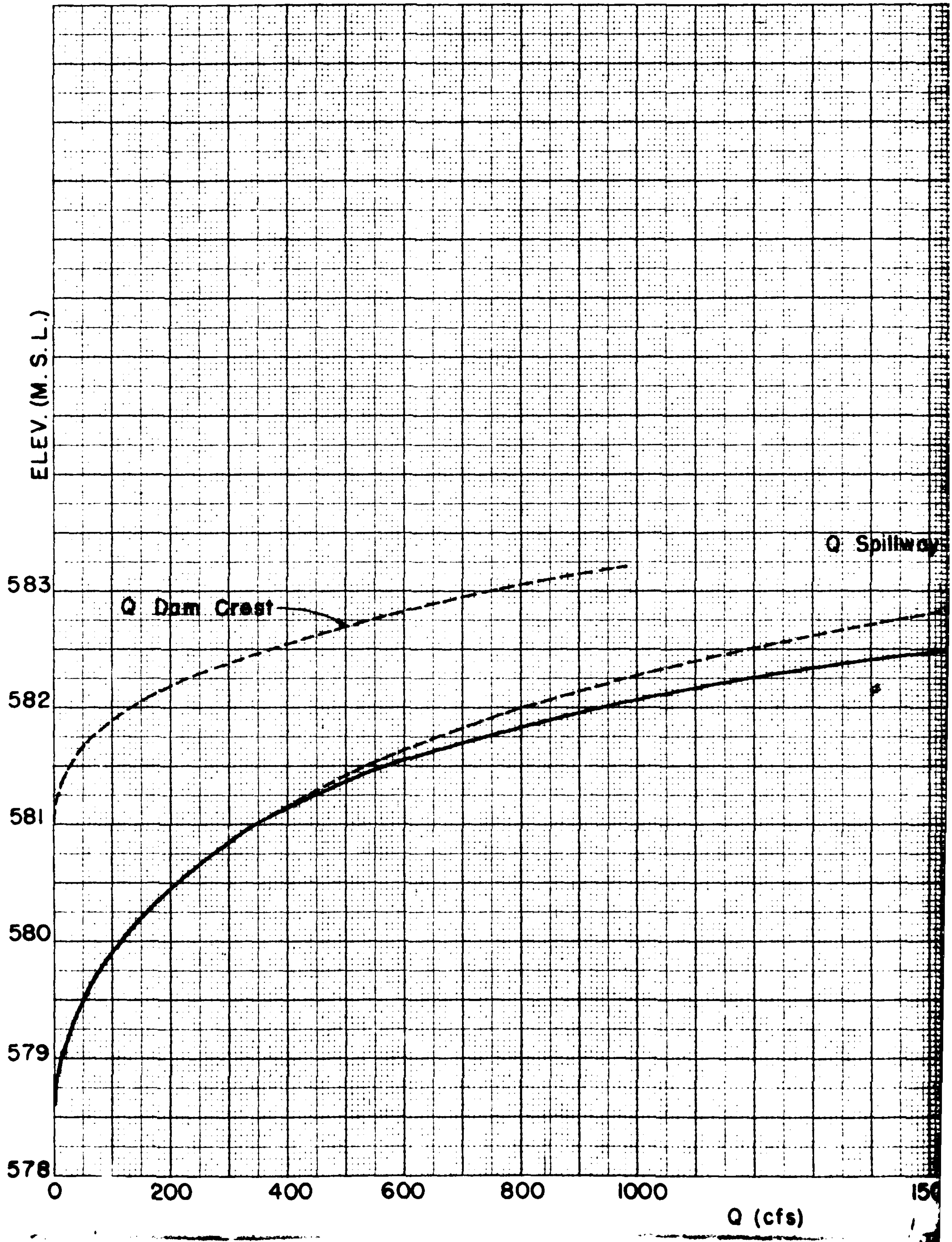
PROFILE SPILLWAY ℄
SCALES: 1" = 5' V., 1" = 50' H.

CRYSTAL LAKE

DAM & SPILLWAY PROFILES

Horner & Shifrin, Inc. August 1978

PLATE 3



ELEV. (M. S. L.)
583
582
581
580
579
578
Q Dam Crest
Q Spillway
0
200
400
600
800
1000
150
Q (cfs)

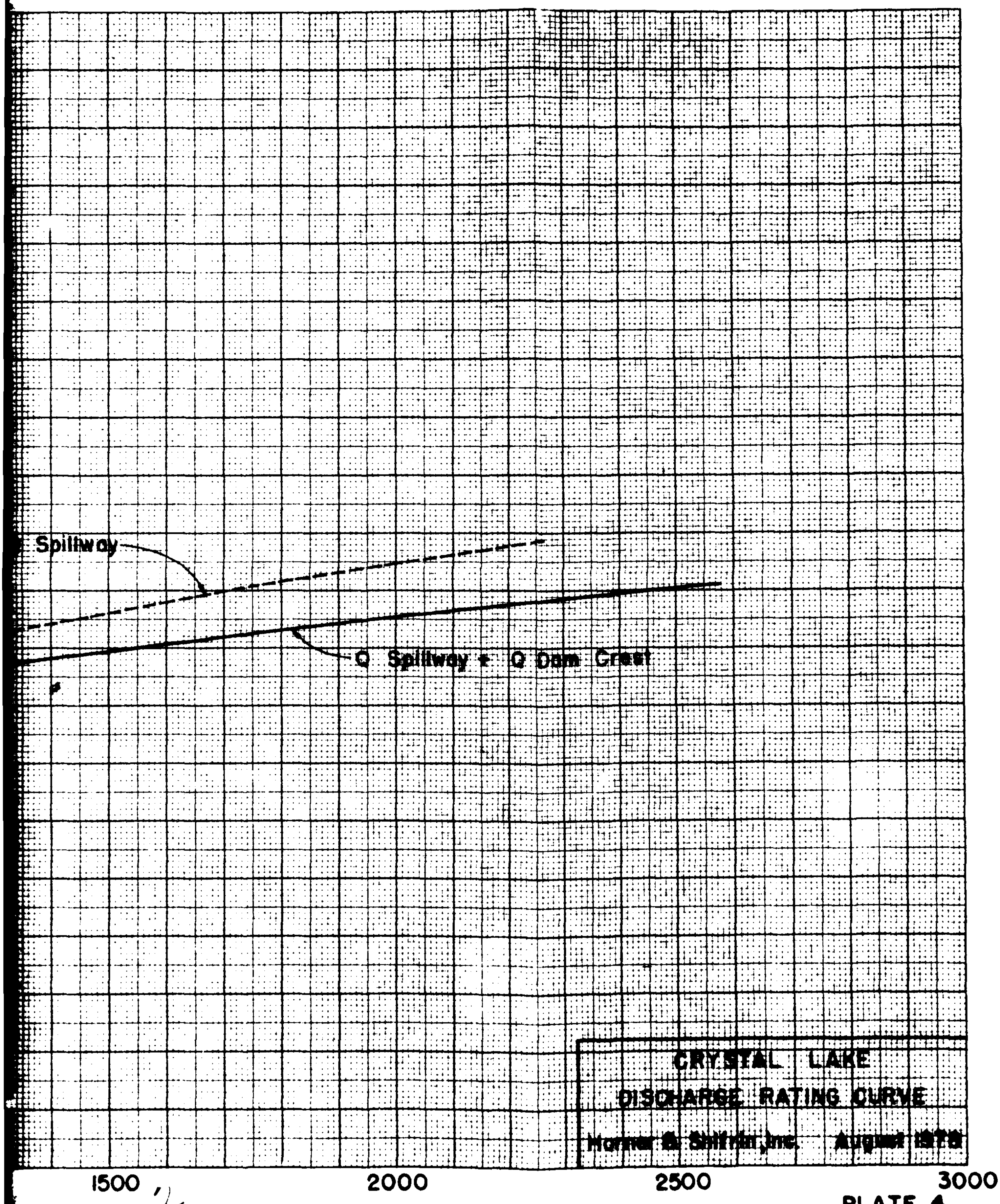
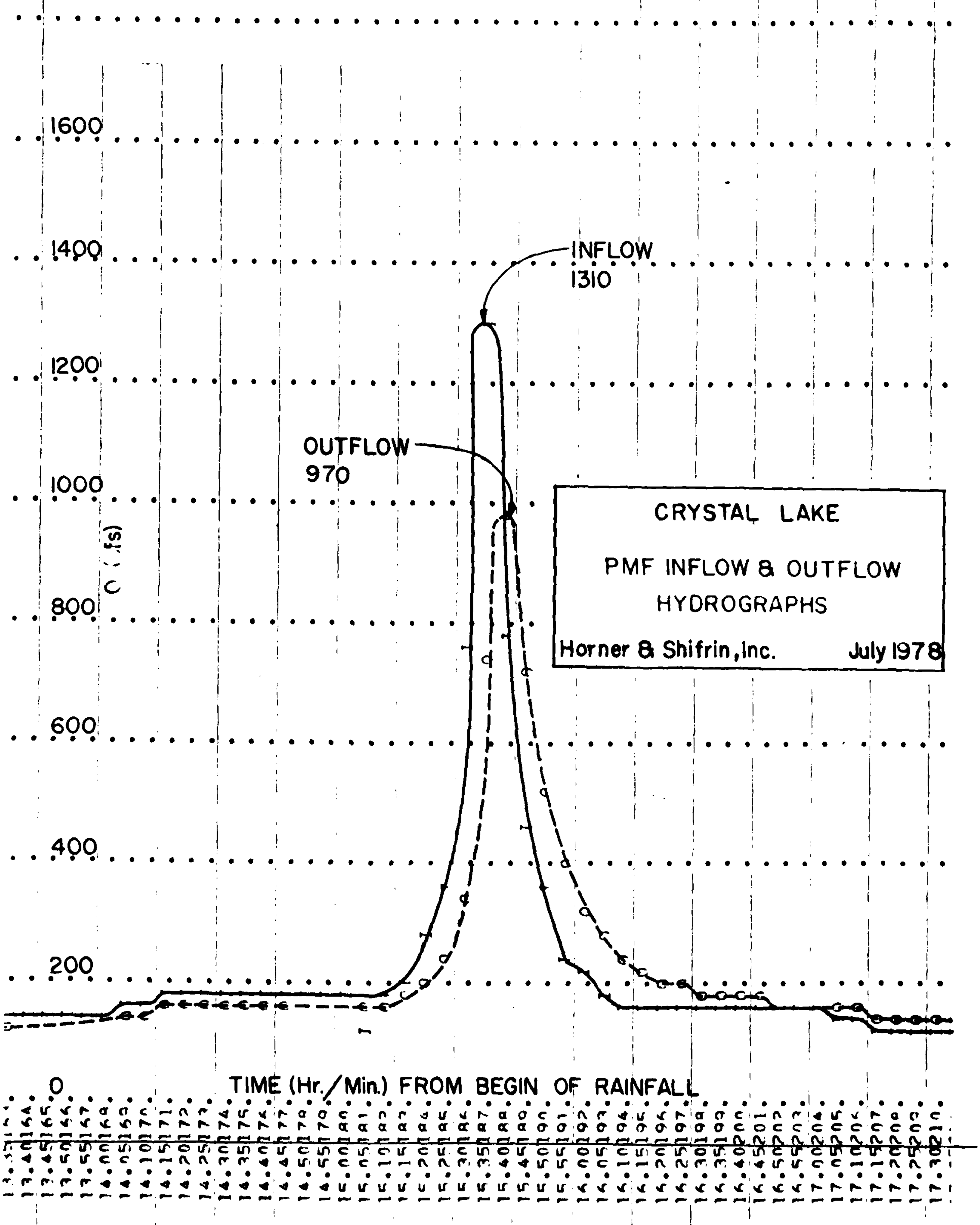

Spillway
Q Spillway + Q Dam Crest
CRYSTAL LAKE
DISCHARGE RATING CURVE
Horner & Shifrin, Inc. August 1978
1500
2000
2500
3000

PLATE 4



CRYSTAL LAKE
PMF INFLOW & OUTFLOW
HYDROGRAPHS
Horner & Shifrin, Inc.
July 1978
INFLOW
1310
OUTFLOW
970
1600
1400
1200
1000
800
600
400
200
0
TIME (Hr./Min.) FROM BEGIN OF RAINFALL

dom in note

8:00 AM

...GIC RECONNAISSANCE OF LAKEWOOD HILLS EAST LAKE

JEFFERSON COUNTY, MISSOURI

...CATION: The east lake - NE¼, NE¼, NW¼, Section 33, T. 43 N., R. 3 E., Pacific Quadrangle.

9-2

A reconnaissance investigation of leakage problems at the lake was made with Mr. Blaine Ulmer to determine if leakage can be corrected at the east lake.

Sandstone of the St. Peter Formation is the parent bedrock in the lake basin and stream bed downstream of the dam.

A considerable flow of water is moving at the contact between the sandstone bedrock and the earthen fill of the dam. The flow is from the water line all the way to the valley bottom on either side of the dam with the water appearing as seeps and springs on the downstream side of the dam. This water collects in the stream bed some 100 to 200 yards downstream as a considerable flow (not measured).

The St. Peter is relatively impermeable vertically except for the upper foot of, weathered rock and where large vertical joints exist. Considering the amount of flow coming under the dam and that collecting as a concentrated source in the stream bed below the dam sufficient water loss is moving under the dam to lower the water line as it appears on the date of this investigation. An interceptor core, therefore, on the downstream toe of the dam seated a foot or so into bedrock should effectively intercept this horizontal movement of water at that shallow depth.

RECOMMENDATIONS:

1. It is recommended that a core trench be excavated into the bedrock on the downstream toe of the dam until fresh rock is exposed in the trench. The trench should then be backfilled with compacted clay with the new core lapped up onto the back face of the dam to provide a seal. If sources of clayey borrow material are available for the backfilling operation, this should be a relatively inexpensive and effective method of eliminating a major portion of the seepage from the lake.

If the lake could be drained, then the new core could be excavated on the upstream toe of the dam across the valley bottom and up both abutments to the water line. If, however, the core is placed on the downstream toe, an effective seal between the new core and the existing back face of the dam can be made. The core would be just as effective and more easily constructed in this area.

Additional drainage into the lake could be made by the use of diversion ditches to add more watershed and therefore, inflow into the lake. The lake to drainage ratio is very small so the lake does not fill as rapidly as it should and a constant flow of water is not present in the shallow subsurface.

A previous report by Whitfield on this lake for a Mr. Larry Meusch stressed sealing of the soil on the inside of the lake to prevent water from moving around and under the dam. This method would be effective if the bentonite were applied in a fashion where the entire bottom area below the water line was sealed (a copy of the report is included).

In summary, the original dam was not properly cored so a new core constructed on the downstream side of the dam should effectively eliminate the shallow water loss that is now taking place around both ends of the dam and probably under the center of the dam.

Thomas J. Dean, Geologist
Applied Engineering & Urban Geology

Geology & Land Survey
June 18, 1976

TEL: (314) 364-1752

cc: Blaine Ulmer
425 Park
Glendale, MO 63038 (w/encl.)

Chart 2-1

9-29-76

Layne-Western Company, Inc. A Marley Company

225 Grand Avenue · P.O. Box 3766 · Kirkwood, Missouri 63122 · 314/965-3924

September 17, 1976

Mr. George Cyrus
2929 Central Street
Evanston, Illinois 60201

Re: Lake Wood Hills
Eureka, Missouri

Dear Mr. Cyrus;

In accordance with our phone conversation, I inspected the larger dam at the referenced site.

At the time of the visit the lake was about 9 feet below the normal level and probably about 15 feet below the spillway level. It is understood that the water level has continued to decline for the past two (2) years and has never been high enough to flow over the spillway. The lake, when full, covers about 6 acres and has a drainage area in the order of 30 acres.

Seepage is evident at the downstream toe of the embankment. It appears there is slightly more seepage on the left side (looking downstream) than on the right. Rock is exposed in the valley downstream of the dam. I only went about 200 feet downstream and in this area seepage was emerging from fractures in the rock. There appeared to be in the order of 15 to 30 gallons per minute of water flow in the valley. A portion of this flow would be from the sewer discharge.

There is no doubt that the leakage is contributing to the low lake level, the main problem is the small drainage area for the lake size. This, combined with the below normal rainfall, appears to be the main reason for the lake level. (The rainfall at St. Louis is 10 inches below normal.)

Of course, prevently or reducing the leakage would improve the situation. This could be accomplished by either grouting the fracture in the rock or lining the lake with an impervious lining. As there is no subsurface information, the amount or type of grouting required is not known. At present, it appears that, if a

9-29-76

Mr. George Cyrus
2929 Central Street
Evanston, Illinois 60201

September 17, 1976

lining were installed, it would be necessary to drain the lake to line the entire reservoir. An investigation may indicate otherwise.

Based on the visible leakage it may be difficult to keep the lake full even if the leakage is stopped. An alternative to stopping the leakage would be to install a well adjacent to the lake and keep the lake full by pumping.

As the lake has never been full and as the water level has been down for some time, it would be advisable to carefully observe leakage conditions as the lake level rises.

If we can be of further assistance in this matter, let us know.

Yours very truly,

Marion C. Skouby

Marion C. Skouby, P.E.
Chief Soils Engineer

MCS/bth

Chart 2-3

SEEPAGE INVESTIGATION
CRYSTAL LAKE
LAKEWOOD HILLS
JEFFERSON COUNTY, MISSOURI

November 18, 1976

LAYNE-WESTERN COMPANY, INC.
225 Grand Avenue
Kirkwood, Missouri 63122

SEEPAGE INVESTIGATION
CRYSTAL LAKE
LAKEWOOD HILLS
JEFFERSON COUNTY, MISSOURI

INTRODUCTION

This report summarizes the results of an investigation into leakage from Crystal Lake in the Lakewood Hills Development.

The lake was constructed in 1966 and consists of an earth embankment which is about 30 feet high at the center of the valley. The lake has an open channel spillway at the north abutment which is about 26 feet above the deepest part of the lake. Seepage has been occurring ever since the lake was constructed. Thus far, the lake level has not reached the spillway. The watershed to the lake is about 39 acres and, when full, the surface area of the lake would be about 4.7 acres. No subsurface information for the lake is available. The topography of the area is shown on Figure 1.

This investigation consisted of measuring the amount of seepage at 2 locations downstream of the dam, recording changes in the lake level, determining the approximate surface area of the lake, and a visual inspection of the area.

SITE INSPECTION

Seepage was evident along the toe of the dam and downstream of the dam. It appeared there was slightly more seepage on the north side. Downstream, in the ravine, water was emerging from the intact rock as well as fractures in the rock. The amount of seepage varied considerably. The visual inspection only extended about 750 feet downstream of the dam. It appeared that very little additional water was entering the ravine more than 650 feet downstream.

It appeared that the valley was widened to provide embankment material. This is particularly true at the north abutment where sandstone is exposed.

SEEPAGE MEASUREMENTS

Stream flow measurements were made at two (2) locations downstream of the dam. Measurements were made by installing a "V" notch weir in the stream. The measuring point nearest the lake was about 150 feet downstream of the dam and the other measuring point was about 650 feet downstream. The measured flow at the two (2) locations was 2.2 gallons per minute and 4.9 gallons per minute respectively.

LAKE LEVEL

A water level recorder was installed on the lake on October 15 and removed on November 2, 1976. The recorder plot is shown on Figure 2. On October 19 there was 0.5 inches of rain and there was 2.1 inches of rain on October 23 and 24. Also 1 inch of rain fell on October 29 and 30. As is evident from the plot, the lake level dropped except during periods of rain. The initial rate of drop (before 10/19/76) was 0.37 inches per day or about 14.3 gpm. The rain on October 19 resulted in a slight rise in the lake level. The immediate runoff was only about 4.2 percent of the rainfall on the watershed. From October 19 to 23 the lake level lowered at a rate of about 0.30 inches per day indicating some continued runoff. On October 23 and 24, about 2.1 inches of rain occurred which resulted in a 3.4 inch rise in the lake. The immediate runoff was about 8.4 percent of the total rainfall. The rate of decline in the lake level afterward was 0.27 inches per day. On October 29 and 30 an additional one inch of rain occurred, which raised the lake level 2.1 inches and an indicated runoff of 11.0 percent of the total rainfall. The subsequent lowering of the lake was at about 0.26 inches per day.

As it was relatively dry prior to the time the recorder was installed, the initial rate of fall in the lake level was probably not affected to a great extent by recharge. As a result, it appears that the rate of leakage from the lake is about 14.5 gpm for the lake level at the time. The rate of leakage would increase some if the lake were full. The amount of increase is not known, but it probably would not be more than about 25 percent. At a leakage rate of 14.5 gpm the total loss would be about 7,500,000 gallons as shown on Figure 3.

RAINFALL

Rainfall records for the immediate area of the lake are not available. Records are available for the weather station at the International Airport at St. Louis. Although this data would not be exactly the same, it would be similar and is therefore used in this evaluation. The average yearly rainfall is 35.9 inches and the average monthly rainfall is as follows:

MONTH	AVERAGE RAINFALL (inches)
January	1.85
February	2.06
March	3.03
April	3.92
May	3.86
June	4.42
July	3.69
August	2.87
September	2.89
October	2.79
November	2.47
December	2.04

The average runoff for each month is not known but would no doubt be greater than the apparent rates of runoff measured. The average yearly runoff to make up the 14.5 gpm leakage would be about 20 percent. A plot showing 20 percent runoff for each month is shown on Figure 3.

CONCLUSIONS

It is considered that seepage loss is through the sandstone bedrock which is exposed in the bottom and sides of the lake. The water appears to be transmitted through joints in the formation as well as through the intact rock. About one-third (1/3) of the leakage enters the ravine within about 650 feet of the dam. Some of the remaining leakage may enter the ravine further downstream or may remain in the bedrock formation.

For the amount of leakage, the size of the watershed is marginal. Past experience with the lake and results of this study indicate that average rainfall just balances the leakage and evaporation from the lake when the lake level is 6 to 8 feet below the spillway level.

It is considered that the most practical method of reducing the leakage to an acceptable level would be line the lake. This would involve draining the lake, removing the

sediments, and installing the lining. The lining could be a natural clay. The thickness of the clay lining would depend on the materials used.

Other considerations would be to grout the bedrock formation or to construct a clay core which would extend across the valley. It is considered that grouting would not be very practical because the sandstone is relatively tight. A clay core across the valley would not be very effective since only a small portion of the leakage could be prevented in this manner. At best, the leakage could be reduced two or three (2 or 3) gpm. If the clay core were constructed at the downstream toe of the existing dam it would be necessary to increase the width of the embankment to withstand the hydrostatic pressures which would be at the toe of the dam.

The maxi um depth of the lake at the time of the investigation was about 15 feet. The estimated amount of water in the lake for this depth is about 5.4 million gallons. For a pumping rate of 1,000 gpm (6-inch pump) it would take about 4 days to remove the water.

An alternative method of maintaining the lake full or nearly so would be to add water. This could be accomplished by constructing a well adjacent to the lake. It would be

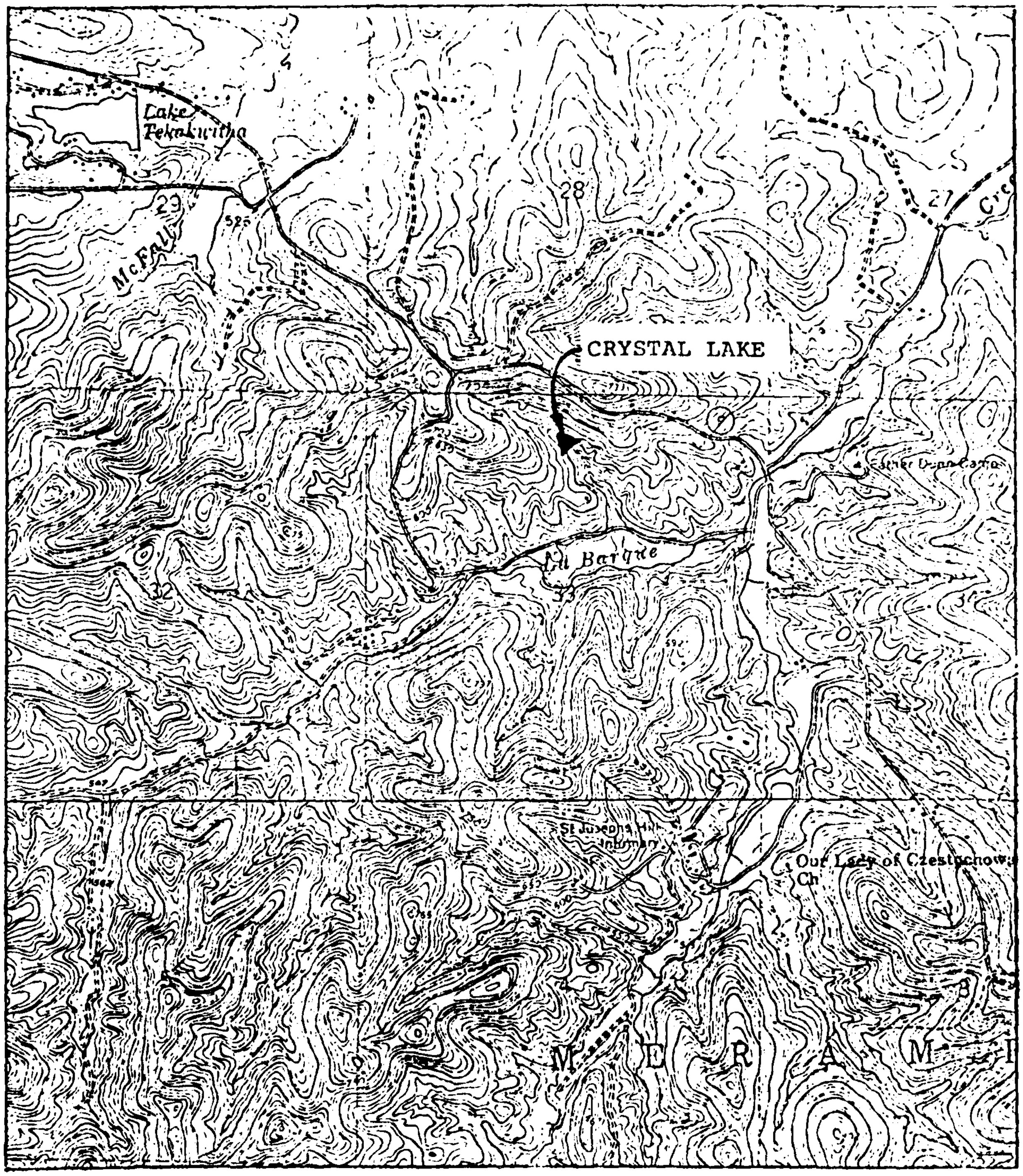
necessary to add water at a rate of about 20 gpm and it would be preferable to be able to add water at a rate of about 35 gpm.

Respectfully submitted,

Marion C. Skouby

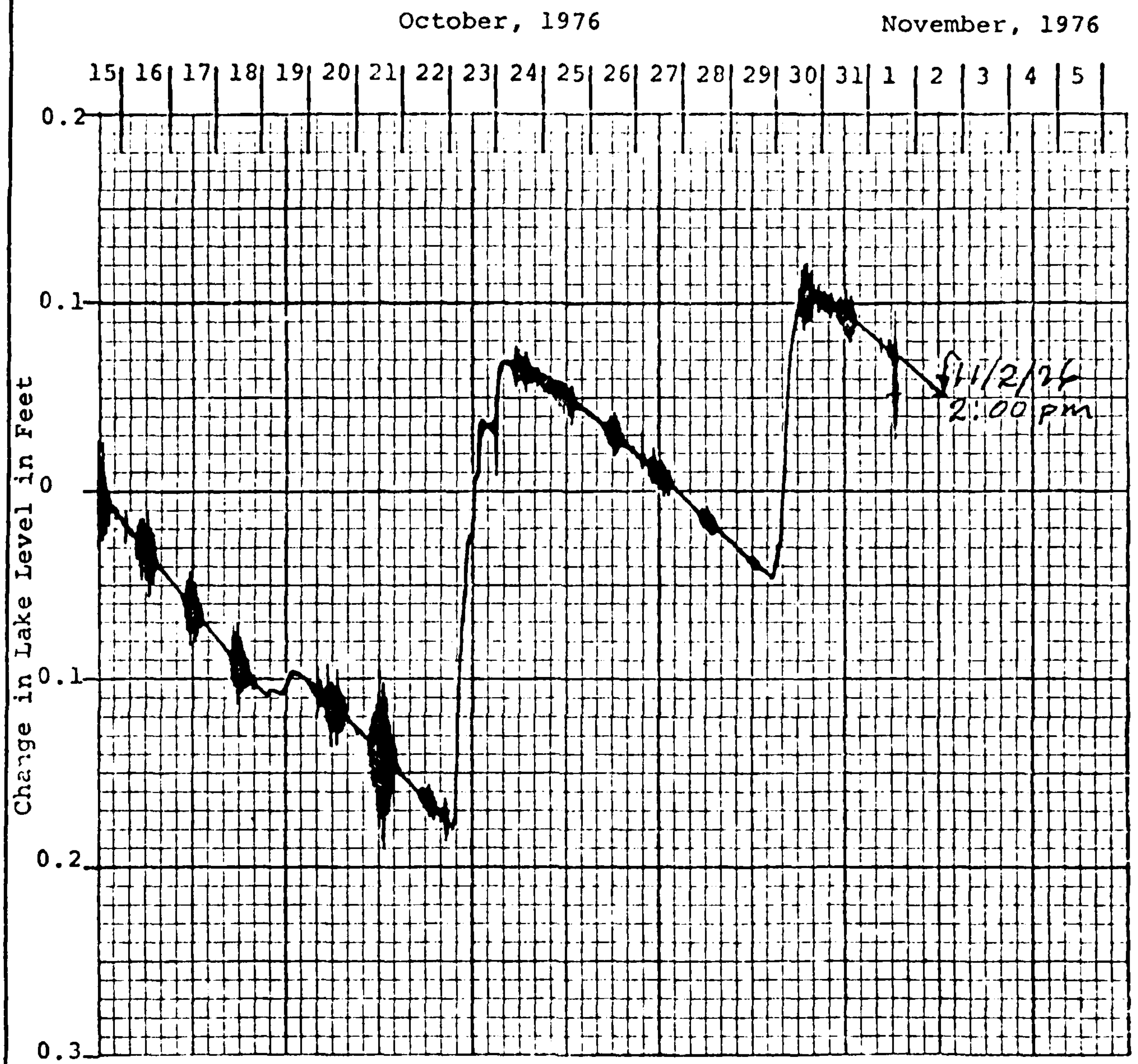
Marion C. Skouby, P.E.
Chief Soils Engineer

MCS/bth



LOCATION OF LAKE

Figure 1 Chart 2-12

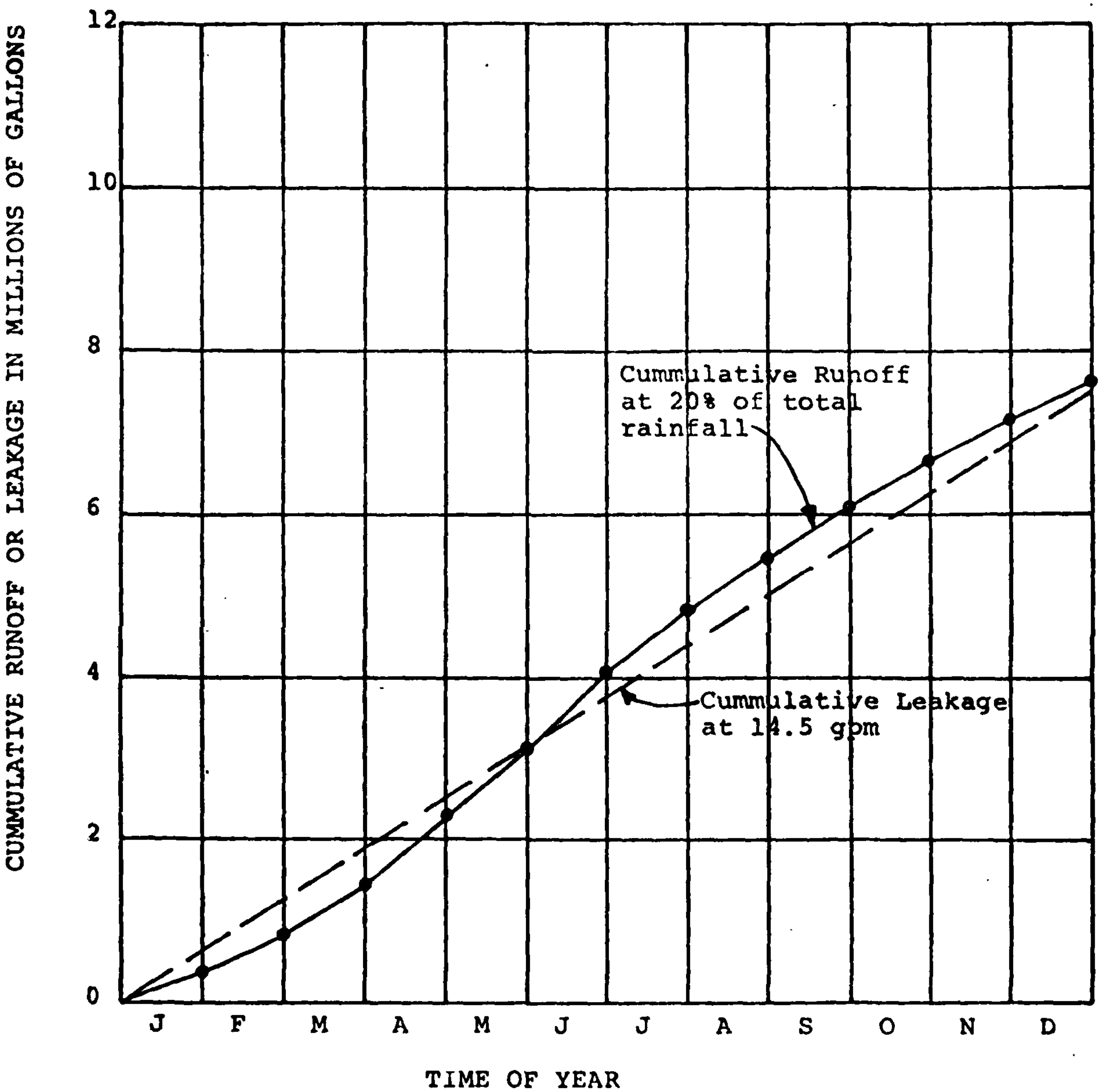


LAKE LEVEL MEASUREMENTS

Figure 2

Chart 2-13

LAYNE WESTERN COMPANY, INC.



CUMMULATIVE RUNOFF
and LEAKAGE

Figure 3

APPENDIX

NO. 1: UPSTREAM FACE OF DAM

NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: EARTH SPILLWAY

NO. 4: UPSTREAM END OF CULVERT FOR SPILLWAY OUTLET CHANNEL

NO. 5: SANDSTONE OUTCROPPING

NO. 6: 2" DRAWDOWN PIPE

HYDROLOGIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.6 inches) from Hydrometeorological Report No. 33. One hundred year frequency (point source precipitation, 24-hour value equals 7.23 inches) from U.S. Weather Bureau Technical Paper No. 40.

b. Drainage area = 0.07 square miles
= 45 acres

c. SCS parameters
Lag time = 0.04 hours
Soil type CN = 80

2. The spillway section consists of a broad-crested, approximately V-shaped excavated earth section with sparse grass cover for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

(1) Spillway crest section properties (area, a and top width, t) were computed for various depths, d.

(2) It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth (Q_c) was computed as $Q_c = \left(\frac{a^3}{t} g\right)^{0.5}$ for the various depth, d.

Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.

(3) Static lake levels corresponding to the various Q_c values passing over the spillway were computed as critical depths plus critical velocity head ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

3. The profile of the dam crest is irregular and flow over the dam crest cannot be determined by conventional weir formulas. Flow quantities overtopping the dam crest were computed as described in the preceding paragraph and corresponding flow over the dam and spillway for given elevations were added to obtain the combined outflow rating curve for the dam and spillway. This rating curve is shown on Plate 4. Inflow-outflow hydrographs for the PMF are presented on Plate 5.

UNIT

```
*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78
*********************************
    1          A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
    2          A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF GEO J CYRUS DAM
    3          A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
    4          B     289       0       5      -0      -0      -0      -0      -0      -0      -0
    5          B1      5
    6          J       1       3       1
    7          J1   0.29    0.50    1.00
    8          K       0  INFLOW                              3       1
    9          K1       INFLOW HYDROGRAPH
   10          M       1       2    0.07                   1.00                               1
   11          P       0    25.6     102     120     130
   12          T                                                     -1     -80
   13          W2           0.04
   14          X    -1.0    -.10     2.0
   15          K       1     DAM                       2       3       1
   16          K1       RESERVOIR ROUTING BY MODIFIED PULS
   17          Y                               1       1
   18          Y1      1                                             50      -1
   19          Y4  578.6     579   579.5     580   580.5     581   581.5     582   582.5     583
   20          Y5      0      10      50     120     220     340     560     940    1570    2470
   21          $A      0     3.9     4.1     6.9    10.1
   22          $E  540.1   578.6     580     590     600
   23          $S  578.6
   24          $D  580.3
   25          K      99
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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78
*********************************
   1          A1      ANALYSIS OF DAM OVERTOPPING USING 100 YR FLOOD
   2          A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF GEO J CYRUS DAM
   3          A3      100 YR FLOOD ROUTED THROUGH RESERVOIR
   4          B     288       0       5      -0      -0      -0      -0      -0      -0      -0
   5          B1      5
   6          J       1       1       1
   7          J1    1.0
   8          K       0  INFLOW                              3       1
   9          K1      INFLOW HYDROGRAPH
  10          M       0       2    0.07                   1.00                       1
  11          O     288
  12          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  13          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  14          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  15          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  16          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  17          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  18          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  19          O1   .007    .007    .014    .014    .014    .014    .014    .014    .014    .014
  20          O1   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
  21          O1   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
  22          O1   .014    .014    .014    .014    .014    .014    .014    .014    .022    .022
  23          O1   .022    .022    .022    .022    .022    .022    .022    .022    .022    .022
  24          O1   .022    .022    .022    .022    .022    .022    .031    .031    .031    .031
  25          O1   .031    .031    .061    .061    .061    .061    .061    .061    .132    .132
  26          O1   .132    .253    .253    .555    .830    .385    .253    .132    .132    .132
  27          O1   .061    .061    .061    .061    .061    .061    .031    .031    .031    .031
  28          O1   .031    .031    .022    .022    .022    .022    .022    .022    .022    .022
  29          O1   .022    .022    .022    .022    .022    .022    .022    .022    .022    .022
  30          O1   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
  31          O1   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
  32          O1   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
  33          O1   .014    .014    .014    .014    .014    .014    .007    .007    .007    .007
  34          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  35          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  36          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  37          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  38          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  39          O1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
  40          O1   .007    .007    .007    .007    .007    .007    .007    .007
  41          T                                                      -1     -80
```

```
O1  .007     .007     .007     .007     .007     .007     .007     .007
T                                                         -1       -80
W2           0.04
X   -1.0     -.10     2.0
K      1      DAM                          2        3        1
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                                 1        1
Y1     1                                                  50       -1
Y4 578.6      579    579.5      580    580.5      581  581.5      582    582.5      583
Y5     0       10       50      120      220      340    560      940     1570     2470
$A     0      3.9      4.1      6.9     10.1

$E 540.1    578.6      580      590      600
$$ 578.6
$D 580.3
K     99
```